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Targeting Erosion Control

Economic Effects

A Report from a National Research Project

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TARGETING EROSION CONTROL: ECONOMIC EFFECTS. By Harold Stults, Robert Dawson, Daryll Raitt, and Jerry Williams. Published by the Economic Research Service, U.S. Department of Agriculture. Conservation Research Report No. 36.

ABSTRACT

Economic effects of targeting soil erosion control were estimated for eight counties in four states in major erosion areas of the Nation. The targeting effort combined with ongoing conservation programs increased net benefits of USDA erosion control programs by concentrating efforts on highly eroding soils and by encouraging adoption of conservation tillage practices. Further gains can be made if more attention is given to financial effects on farmers, long-term productivity, offsite damage, and economically efficient practices. There are erosion control practices in each study area that provide benefits in excess of costs even when offsite benefits are not counted.

Keywords: Targeting, economic effects, soil conservation, conservation tillage, erosion control, long-term productivity, net returns, present value.

Washington, D.C. 20005-4788 May 1987

PREFACE

A national program to target conservation efforts on critical resource problem areas was launched by the U.S. Department of Agriculture (USDA) in 1981. The decision to pursue this policy option for achieving conservation goals came about because of concerns expressed by Congress, conservation agencies of USDA, others in the executive branch, and the public at large. The concerns revolved around the joint observation that whereas resource problems were concentrated in limited geographic areas, USDA conservation efforts were spread rather widely and uniformly throughout agricultural areas of the Nation. Targeting of programs to where problems are concentrated was a central thrust of planning under the Resources Conservation Act (RCA) passed by Congress in 1979, and was seen as a way to increase effectiveness of public expenditures on conservation. While targeting is a USDA-wide program, key agencies in designing and implementing the program are the Soil Conservation Service (SCS) and the Agricultural Stabilization and Conservation Service (ASCS).

USDA's Agricultural Research Service (ARS) and Economic Research Service (ERS) designed and carried out this research on targeting in close cooperation with SCS and ASCS at national, state, and county levels. The objectives were to analyze: (1) the delivery system used in implementing the targeting program, (2) factors associated with farmers' adoption of erosion control practices and identify characteristics of farmers most likely to respond to future conservation programs, and (3) effects of targeting on soil loss, farm income, and long-term productivity.

Researchers on this project did not address the question of whether the federal government should spend more or less on conservation efforts, or indeed whether it should spend any at all. Rather, research proceeded from the premise that because of past history, public interest, constituent demand, and support from both Congress and the executive branch, USDA will continue to spend several hundred million dollars each year on conservation programs. Thus, the research is concerned with whether or not targeting of erosion control funds can lead to greater payoff from public investments made available to USDA.

SCS and ASCS targeted programs for controlling water and wind erosion on crop and rangelands, water conservation, and salinity problems. The research addresses only programs for controlling water erosion on cropland, the resource problem that has highest priority on USDA's agenda and the largest proportion of targeted funds and personnel.

The researchers recognized that soil erosion problems vary among regions. The conservation problem encompasses all physiographic and socioeconomic areas across the country, to which different approaches to program design and execution may be relevant. The decision was made to study the targeting program in detail in two counties in one state in each of four major erosion areas that USDA targeted starting in 1981: Alabama in the Coastal Plains, Missouri in the Corn Belt, Tennessee in the Mississippi Valley Uplands, and Washington in the Palouse area of the Pacific Northwest. The general approach in the research was to start with objectives of the targeting program to see how they were translated into an operating program in the field, and then to trace through effects of the program on farmers' adoption of erosion control practices, farm incomes, and soil productivity.

Four reports have been published by ERS under the general title Targeting Erosion Control:

- o Basebook--Methods and Data, Conservation Research Report No. 32, July 1985. Provides detailed data from personal interviews with 709 farmers in the four study states.

- o Delivering Technical and Financial Assistance, Conservation Research Report No. 33, October 1985. Describes how the targeting program operated and impressions and attitudes of farmers, agency staff, and others involved in the program.

- o Economic Impact of the Conservation Targeting Program: Daviess and Harrison Counties, Missouri, ERS Staff Report AGES850903, July 1986. Provides details of procedures and results of economic impact analysis for Missouri.

- o Adoption of Erosion Control Practices, ERS Staff Report AGES860815 August 1986. Examines factors influencing adoption of conservation practices.

Study leader James Nielson authored an article in the Journal of Soil and Water Conservation (March-April, 1986) titled "Conservation Targeting: Success or Failure?" The article reviews examples where targeting has improved the conservation program and makes suggestions on how the program could be improved.

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SUMMARY

Targeting made the USDA erosion control program more economically efficient by focusing on highly erosive soils and encouraging the use of conservation tillage. Further improvement is needed to assure that erosion control practices supported by USDA provide public benefits that are greater than public costs. More attention needs to be given to calculating long-term productivity benefits, selecting the most economically efficient practices or set of practices, and in estimating offsite benefits.

The effects of erosion control vary among farmers, communities, and the public. Farmers look to profits from the use of their land. If erosion control can increase the present value of net returns over time, farmers will find it in their interest to adopt erosion control practices. In each study area, there were some cases where it was profitable for the farmer to use certain conservation practices, usually some form of conservation tillage. In these cases, public support other than providing information or perhaps technical assistance may not be required to achieve conservation goals. Public financial support of erosion control is justified when public benefits are positive but private benefits are not.

Public benefits accruing from erosion control include maintaining the long-term productivity of agriculture and improving environmental quality by reducing offsite damage caused by sediment from cropland erosion. In estimating the present value to the public of maintaining soil productivity by reducing erosion, we used a 4-percent discount rate. This contrasts to a 12-percent rate for estimating benefits to the farmer. When long-term benefits and costs are discounted at a 4-percent rate, net present value is generally higher than when a 12-percent discount rate is used. Where public benefits of maintaining soil productivity are positive, but private benefits are not, public cost-sharing of conservation practices with the farmer is justified and necessary to achieve conservation goals.

Offsite damage caused by sediment may be greater than productivity losses and other damage to the land where erosion is occurring. But, it is generally not possible to make reliable estimates of offsite damage of cropland erosion. We report the results of research on offsite damage in one of the study areas, but we did not include estimates of offsite benefits of erosion control in our analysis. This means that our estimates of public benefits of erosion control may be seriously underestimated.

Erosion control can affect the amount of income flow in communities. As farmers change practices, they may change the amount of inputs they buy and the kind and amount of products they market. Under the targeting program, federal agencies increased spending in the targeted area both to assist farmers with costs of erosion control and for salaries and other costs for personnel to provide technical and financial assistance. In the study areas, the erosion control program was not large enough to cause major differences in community income flows. Secondary economic effects would become a major concern only if an erosion control program resulted in a large amount of cropland taken out of crops.

Targeting highly erosive areas made the targeting program more efficient than the ongoing erosion control program. But the benefit per ton of erosion reduction varies widely across the country and among practices. Thus, benefits as well as costs must be evaluated to determine where erosion control

practices should be adopted and which practices are most economically efficient. Practices that are most effective in reducing erosion often do not give the largest net benefits.

In all four study areas, conservation tillage was highly effective in reducing erosion and at a lower cost than other practices. To assure that this highly efficient practice is not overlooked, we recommend that conservation tillage be considered as the first element in every conservation plan.

Targeting Erosion Control

Economic Effects

INTRODUCTION

This report presents selected findings of four separate studies of economic effects of targeting erosion control. Targeting accelerates conservation treatment in areas with critical erosion problems. Conclusions and suggestions for improving targeting programs provide information useful to those involved in soil erosion control: policymakers, administrators, program managers, and those who "put conservation on the ground."

Specific Study Objectives

This study estimates economic effects of efforts to achieve targeting goals. Perspectives of farmers, the community, and the Nation are analyzed. Farmers experience changes in net returns, overall soil productivity, and land values. Community income flows change when there are changes in agricultural production, cost-sharing funds, and salaries for employees providing technical and financial assistance. The Nation is affected by changes in national economic efficiency, agricultural productivity, and environmental quality. We compare effects with erosion control to without control. Even with erosion control, damage may continue but at a slower rate than without control. Positive net benefits do not mean that net returns are increasing in an absolute sense, only relative to what they would have been without erosion control.

Concept of Targeting

Targeting concentrates program resources on high-priority problems. Even though they may not use the term, managers apply the concept whenever they use benefit-cost analysis, management by objective, zero-based budgeting, or other processes for establishing priorities and reallocating resources to focus attention on selected activities, programs, projects, groups, or areas. Targeting as a concept is easy for public decisionmakers to agree to in principle. But problems frequently arise in deciding on criteria for selecting targets, who is to select them, processes that are to be used in carrying out the targeted program, and on funding, especially when funds must be diverted from other regions or purposes.

In initiating the national effort, USDA defined targeting as a strategy for allocating additional program resources to specific geographic areas based on identified critical resource problems, conditions, and needs.

Targeting Objectives and Plans

Key elements of the targeting effort as outlined in the National Conservation Program adopted by USDA in 1981 were:

- o Critical resource problem areas were defined as those where the problem, if untreated, would impair long-term productive capacity and have an effect on national agricultural production.
- o Areas would be targeted until the resource problem has been substantially corrected.
- o Targeted funds would not become a part of the base level of assistance.
- o Extent and duration of the targeting effort would depend on the availability of funds and progress in treating the problems.

Stated objectives of the program for targeting cropland erosion control were:

- o Accelerate application of conservation practices in critical erosion areas.
- o Reduce soil loss.
- o Maintain long-term productivity of agriculture.
- o Reduce offsite damage.
- o Increase cost-effectiveness in solving conservation problems.

These are not mutually exclusive objectives. The first two are ways to achieve the third and fourth. The last objective is a measure of effectiveness of the program. However, only costs are considered; benefit evaluation is needed to complete the economic analysis. The research reported here is an attempt to measure both costs and benefits.

Plans for the targeting program as outlined in the National Conservation Program called for the Soil Conservation Service (SCS) to target 5 percent of its conservation technical assistance (CTA) funds and for the Agricultural Stabilization and Conservation Service (ASCS) to target 5 percent of its Agricultural Conservation Program (ACP) cost-sharing funds starting in 1983. Under the plan, each agency would increase its commitment to targeting by 5 percentage points each year until 25 percent of the funds were targeted in the fifth year of the program, 1987.

Launching the Program

SCS actually launched the targeting program in the spring of 1981, using $4 million of new discretionary funds. The program encompassed cropland erosion control in parts of 10 states, and for water conservation in parts of 8 states (see 3, fig. 4).1/ ASCS joined the national effort in 1982 by reallocating $9 million of its ACP funds for many of the same areas targeted by SCS in 1981-82. In 1983, targeting formally began under the Resources Conservation Act (RCA) 5-year plan. SCS targeted 5 percent of its CTA budget and ASCS targeted 10 percent of its ACP funds. In 1984, SCS targeted 10 percent of its CTA budget. ASCS had planned to target 15 percent of its ACP funds, but for 1985 Congress put a cap on targeting at the 10-percent level for both agencies.

1/ Underscored numbers in parentheses refer to items in References.

ASCS targeted most areas covered by SCS. But, it did not target all of them, primarily because the agency did not have sufficient funds to do so. Agency program costs for targeting of erosion control during 1981-84 totaled $77 million (table 1). Both agencies had planned to expand targeting to the 25-percent level envisioned in the National Conservation Program for 1987 by rolling over funds from previously targeted to newly targeted areas. However, the congressional cap limited funding to the 10-percent level. For detailed cost allocations for areas included in this study, see (2).

National Targeting Guidelines

SCS offered general guidance on the targeting program to the states. The guidance encouraged targeting within counties, use of conservation management systems rather than individual practices, conservation tillage, and developing close working relationships with ASCS in the field. ASCS issued rather specific guidelines on the targeting program for its state offices. This guidance identified 14 erosion control practices eligible for cost-sharing with targeted funds. It also encouraged use of 3- to 5-year mini-LTA's (long-term agreements) with farmers in targeted areas, inclusion of some targeted counties in the variable cost-share pilot program, and consultation by state offices with SCS state conservationists to determine the amount of cost-share funds needed in each targeted county.

Research Focus

The strongest interest of government officials responsible for the targeting program was found in analysis of three areas: the system for delivering the program, factors influencing farmers to adopt conservation practices, and economic consequences of the program. These became the objectives of the study. Figure 1 is a schematic of the overall study. This report deals with economic effects.

Measures of Efficiency

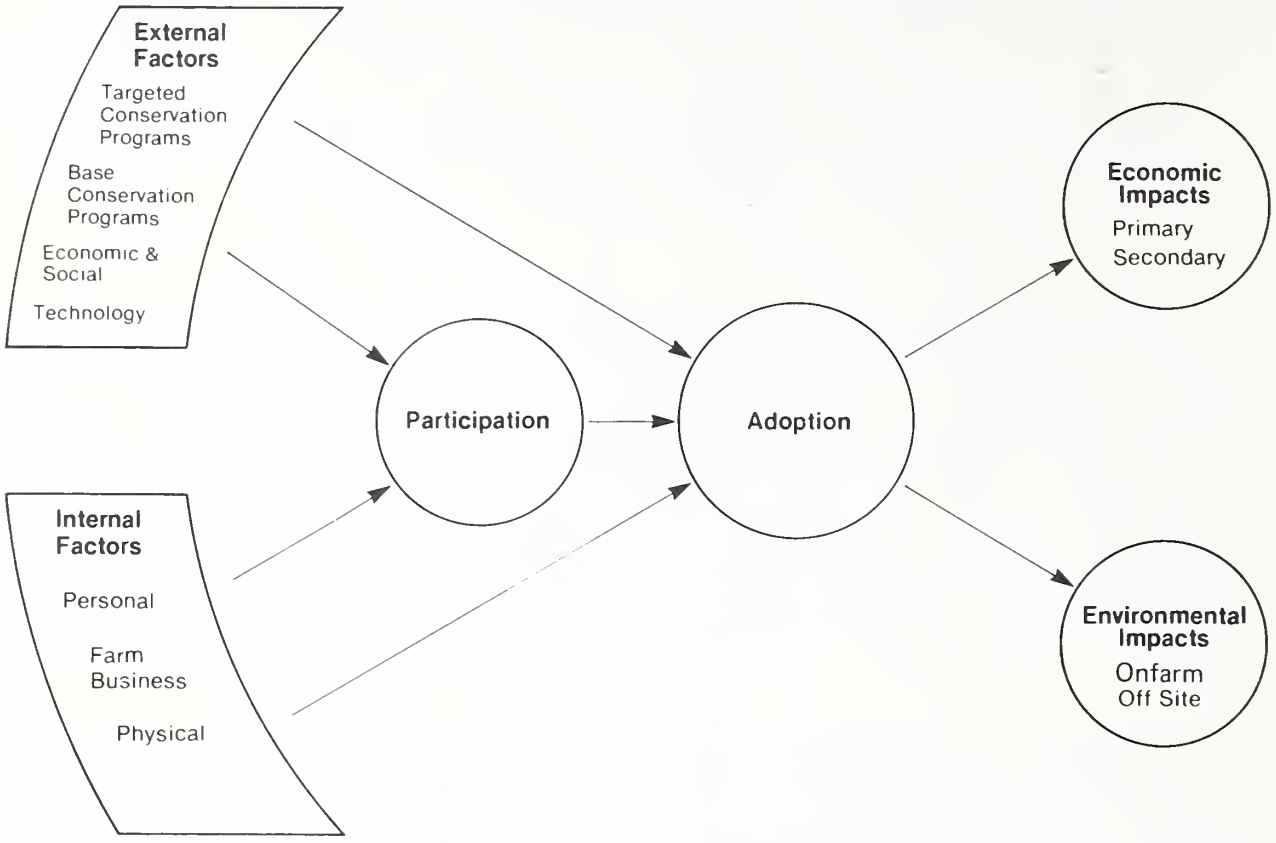
The term efficiency has many meanings. In this report, it is used in two ways: economic and technical. Economic efficiency refers to costs and benefits that are measured in net returns. Technical efficiency is a measure of physical output such as tons of soil erosion reduction. Although economic efficiency is not listed as a program goal (see Targeting Objectives and Plans above), a premise of this report is that economic efficiency is an appropriate measure for evaluating the targeting effort. Furthermore, improving economic

Table 1--Funds targeted for erosion control

Year	SCS	ASCS	Total
		Million dollars	
1981	3.3	0	3.3
1982	5.5	6.5	12.0
1983	10.2	14.2	24.4
1984	22.7	15.0	37.7

Figure 1

Model for Analyzing Erosion Control Programs



efficiency provides justification for cost-sharing and providing technical assistance as well as training and other program features.

Specific Study Concerns

Economic effects of targeting erosion control are analyzed from the perspectives of farmers, communities, and the Nation.

Farmers

The major erosion control benefit to farmers is more net farm income over time. Net returns change when farmers invest in conservation practices, modify their cultural practices, and/or use different cropping patterns. Costs may change because of investment in the practice and different requirements for machinery, labor, fuel, and other inputs. Gross returns vary if yields or land use change. In some cases, costs increase for a few years, then drop to previous or even lower levels. This happened for some farmers when they shifted to conservation tillage. Costs first increased because of higher machinery and chemical costs and lack of experience in using the practice. As farmers gained experience with the practice and as their machinery inventories balanced with needs, per-acre costs declined, sometimes to below what they were before changing practices. In the case of structures such as terraces or diversion structures, there is a high initial investment cost and a yearly maintenance cost.

Productivity benefits result from the value of soil productivity maintained by reducing erosion over time. Productivity losses from erosion usually are initially small because minor erosion of top soil often has little influence on yields. But over time, erosion gradually removes enough top soil so that productivity in the remaining top soil and subsoil is reduced.

Farmers look at the value of productivity loss and compare that value to cost of erosion control practices. Since productivity losses and conservation practice costs occur at different time periods, a method is needed to bring these values and costs to a common time period for comparison. Discounting is a common procedure which calculates a "present value" for future income or cost. Table 2 and figure 2 illustrate both nominal and discounted benefits and costs at 4-percent and 12-percent discount rates.

Benefits of erosion control come from preventing loss of productivity. Net returns do not increase in absolute terms, but do increase relative to what they would have been if erosion had continued unabated. The illustration assumes that without erosion control there would be an annual soil loss that results in reduced productivity. Note how productivity loss is cumulative. In any one year, the loss includes loss due to all past erosion, plus additional loss from erosion in the current year. The assumption for the illustration is that productivity loss each year is 10 cents and that each year the loss from past erosion is 5 percent greater than the previous year. For example, for the first 3 years, loss in productivity without erosion control would have been 10 cents in year 1; 10 cents + 10 cents X 1.05 = 20.5 cents in year 2; and 10 cents + 20.5 X 1.05 = 31.525 cents in year 3. When erosion is reduced by use of erosion control practices, the reduction in loss of productivity becomes the benefit of erosion control.

For this illustration, costs of reducing erosion (minus values in figure 2) are assumed to be $5 per year for each of the first 5 years and $1 per year thereafter. The top part of figure 2 shows these costs and benefits without discounting. The bottom part shows net benefits (benefits minus costs) undiscounted and with 12- and 4-percent discount rates. Present value is calculated by summing net benefits for each year of the time period. Note how

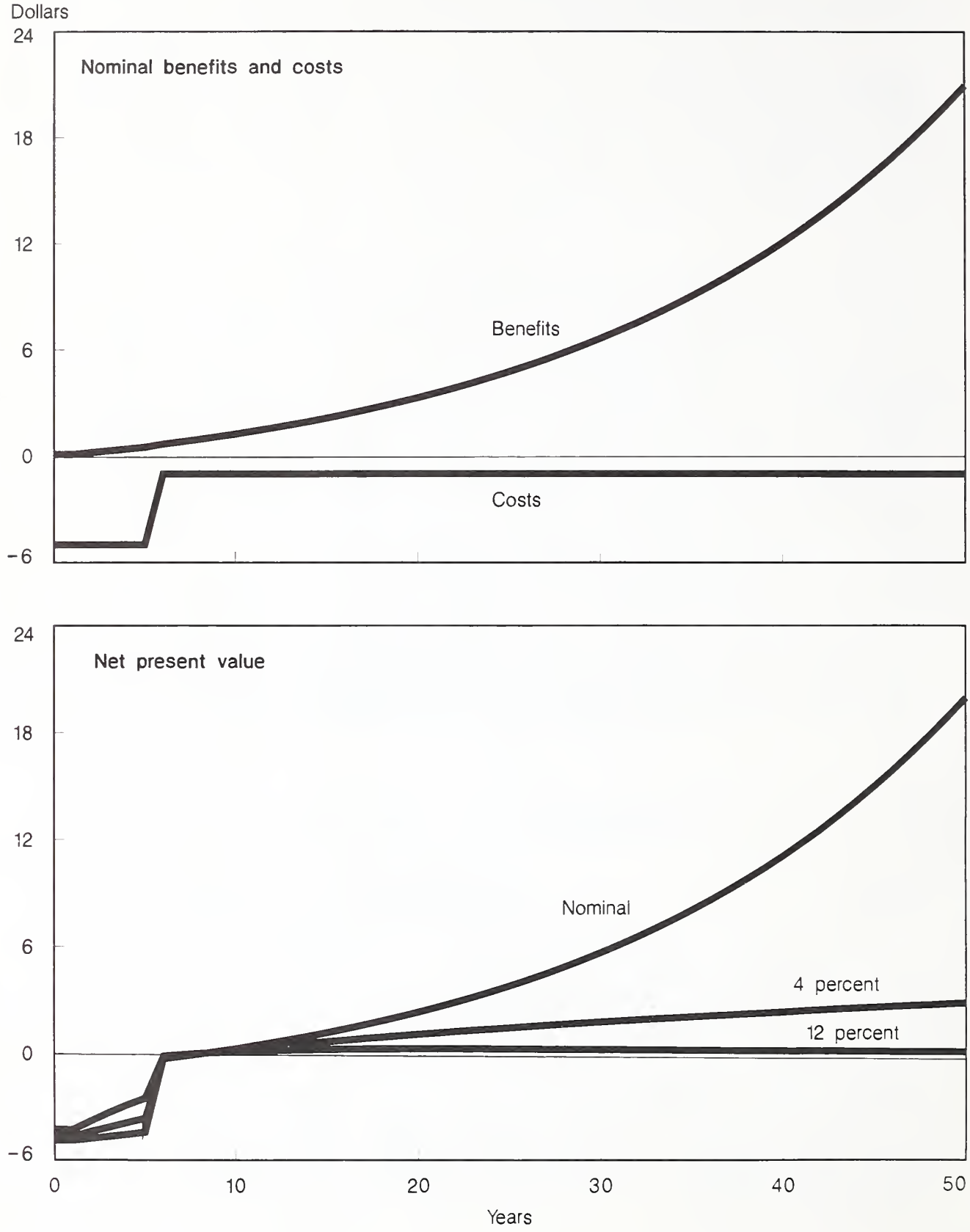
Table 2--Present value of productivity saved and practice costs for selected years, an illustration

Item	Discounted present value in year-- 1	5	10	25	50	50-year total
			Dollars			
12-percent discount rate:						
Productivity saved (benefits)	0.09	0.31	0.41	0.28	0.07	12.20
Practice cost	4.46	2.84	.32	.06	0 1/	22.72
Net present value	-4.37	-2.52	.08	.22	.07	-10.52
4-percent discount rate:						
Productivity saved (benefits)	.10	.45	.85	1.79	2.95	85.89
Practice cost	4.81	4.11	.66	.38	.14	39.29
Net present value	-4.71	-3.66	.27	1.42	2.81	46.60

1/ less than $0.005.

Figure 2

Present value illustration



small present value of distant income is when discounted at 12 percent. The cost of borrowing funds during 1981-84 was approximately 12 percent.

The criteria for selecting a conservation practice involves a comparison of present value of the benefit stream (productivity maintained) and present value of initial and future costs. A farmer, acting rationally, will choose the alternative that will maximize net benefits. For this study, farmer effects are measured in terms of changes in present value of net benefits using information available from each study area. Farmers often include the effect on their taxes when evaluating investments on the farm. Tax effects are not included in this study because the objective is to evaluate the economic effects of the conservation program. It would not be in the public interest for farmers to invest in conservation to reduce taxes unless at the same time the public benefits from conservation are also positive. While the emphasis in the study is on long-term benefits, we recognize that, in some cases, erosion control can have immediate benefits. Sometimes erosion reduces yield because of reduction in plant populations or loss of moisture held in the soil. Sediment may cause onfarm damage as well as damage off the farm. Costs may go up because of gullies caused by erosion. Fertilizer can wash away with the soil, increasing input costs. Harvesting can be made more difficult because of erosion. To the extent that we can identify and measure the short-term benefits arising from the solution of these problems, such benefits are included in estimates of present values. If they are unique to a field or a situation, we did not include them.

Community

Changes in income flows and employment resulting from installing conservation practices are the primary economic effects on the community. To the extent job creation and expenditure patterns result in net gains for the local area, community benefits are positive. Adoption of conservation practices can affect income flows either positively or negatively. Jobs are provided when structures such as terraces are installed, but a shift from crops to pasture may reduce jobs associated with local processing and marketing. Value added locally to products is used as the measure of net economic benefits for the community.

Targeting increased spending for technical assistance and cost-sharing. This type of spending is a transfer of income from outside the community and provides no national income benefits. But, such assistance may provide significant local income and be the basis for state and local support of conservation programs.

National

The Nation has a primary interest in maintaining long-term soil productivity because it helps maintain farmers' income, and because it can help provide a secure, low-cost national food supply. The national perspective also includes offsite damage: economic and environmental damage that sediment causes after leaving the farm.

National economic efficiency is the criterion used to assess contributions of targeting to national objectives. The concept of national economic efficiency can be compared with the size of a pie. If a larger pie (national income) can be obtained with the same total ingredients (resources used), economic efficiency has improved and society is generally better off. National

economic efficiency can also be achieved by reducing costs while still maintaining production levels. Reducing erosion can contribute to national economic efficiency both by increasing total output without increasing costs or by decreasing total costs without also decreasing output.

Offsite effects can be either economic or environmental. Economic effects are measured by economic efficiency criteria. Various quantitative and qualitative procedures can be used to measure effects on the environment. Offsite damage is reported only for the Washington study area where a USDA river basin study (11) made estimates for one basin. Other areas did not have adequate data for such estimates. Existing research and other available information on offsite effects were reviewed for all study areas.

The measure of national economic effects used in this report is social net present value, estimated with the same procedures used to measure farmers' net present value but calculated with different assumptions about discount rates. Social net present value should include benefits from offsite damage reduction. But, data to estimate these values are not available and they are not included as part of social net present value estimates.

Both society and farmers look at the same stream of income change that results when conservation practices are adopted. But, compared with farmers, society in general will tend to discount at lower rates to reflect priorities for maintaining a productive resource for future generations. Table 2 illustrates the effect of varying discount rates on net present values. Net present value is the difference between present value of productivity saved (benefits) and present value of costs of practices adopted.

The public policy objective is to induce farmers to adopt practices consistent with national interests. In order to cover costs in the table 2 illustration, farmers would need cost-sharing of at least $10.52 per acre. USDA uses technical assistance, cost-sharing, education, training, and other means to reduce farmers' costs and induce them to take conserving actions. Regulatory actions, with or without compensation, may be justified to align private objectives with national objectives. The discount rate for estimating present value of future income from a national or societal viewpoint is reflected by cost of borrowing money by government for projects that provide benefits over several decades. The rate should be in real terms with effects of inflation eliminated. Real interest rates vary considerably over time, but average approximately 4 percent over the long term.

Assumptions and Procedures

Proper use of results of this study require that its limitations be understood.

Data Base

For agency accounting, practices applied with targeted resources were kept separate from those applied with annual funds for the ongoing program. These proved to be of no value for analysis since there were no criteria for deciding between using ongoing and targeted funds for technical assistance or cost-sharing. As a result, the full conservation program (both targeted and annual) is evaluated in selected targeted counties. The study attempts to measure economic effects of conservation practices adopted in study areas during the 1981-83 targeting period. From this analysis, statements are made

about effectiveness and economic efficiency of the total erosion control program, including targeting.

Prices and Technology

Prices and technology are assumed to be constant so that only changes resulting from adopting conservation practices are evaluated. In reality, crop prices will change and crop yields can be expected to increase because of technological gains, even with soil erosion.

Erosion Reduction and Soil Loss

The Universal Soil Loss Equation (USLE) is used to estimate soil loss. In fact, USLE measures only movement of soil, sometimes from one point in a field to another. The USLE overstates soil loss, but it is the only measure available. Unless otherwise noted, the analysis deals with only sheet and rill erosion. The USLE measures sheet and rill erosion, but not gully or wind erosion.

Timeframe for Analysis

This analysis measures effects over a 50-year period. This period is used to reflect long-term productivity changes that are an important benefit of erosion control. Required maintenance is assumed to be carried out during the entire period.

OFFSITE AND SECONDARY EFFECTS

Erosion reduction improves downstream water quality by reducing sediment and pollutants attached to sediment. Secondary economic effects occur because of changes in money flows in the local economy.

Offsite

The offsite effects from erosion represent a classical example of the externalities concept. Sediment leaves the field where erosion occurs and causes downstream damage in numerous ways, from siltation to poisoning of fish or animals. Offsite erosion damage is estimated to be large, although only a few studies have attempted to estimate them because of difficulty of obtaining reliable measures.

Offsite damage is difficult to measure for several reasons. First, the very nature of biological systems, fishery resources, and recreation makes it difficult to estimate the value of damage, even when the nature and extent of physical damage is known. For example, estimates of the value of a fish in a stream or a "recreation day" (a measure of time spent in recreation) vary considerably. Second, the relationship between erosion and sediment is very complex and reliable estimates are generally unavailable. In addition, dynamics of sediment delivery are so complex that scientists are yet unable to devise generally accepted rules-of-thumb and ballpark estimates relating erosion to sediment delivery downstream.

When the level of sediment entering most streams is reduced, sediment delivery downstream is not reduced proportionately. The dynamics of stream systems cause streams with a reduced sediment load to pick up sediment from

streambanks and streambeds. New equilibrium with a lower sediment load will be reached eventually, but this could take many years or decades.

Much of the sediment delivered to a stream is during an "event," further complicating the matter. For example, an estimated 85 percent of the sediment delivered to the Columbia River from the John Day River in a 10-year period came from one 6-hour storm event (12).

Despite all these problems, progress is being made in estimating offsite damage. A USDA river basin study in Idaho estimated the value of reduced sediment in the Snake River from erosion in Mission Creek and Lapwai watersheds (10). This area was chosen because offsite damage there is considered to be among the highest in the region. Indepth analysis was done for fisheries, municipal and industrial water users, navigation, flood control, and long-term productivity. The estimated benefit was $3.24 per ton of sediment reduced, about 80 percent of that due to reduced dredging cost at Port of Lewiston. Assuming the proportion of sediment that reaches the stream is 30 percent, we estimate offsite damage per ton of erosion to be $0.97 per ton.

A Conservation Foundation report (1) provided estimates of instream and offstream damage of soil erosion for the United States. Instream damage includes effects on biological uses, recreational uses, water storage facilities, navigation, and other instream uses. Offstream damage includes flooding, sediment in water conveyance facilities, and higher water treatment costs. Over 30 types of damage were estimated. Erosion-related pollutants are estimated to have had a net damage cost of $3.2 billion to $13.0 billion in 1980, with the single-value estimate being $6.0 billion per year. Cropland's share is $2.2 billion.

USDA recently estimated offsite damage reduction achieved by the erosion control program (7). It estimated offsite benefits of erosion control on all agricultural land to average $0.83 per ton of erosion reduction in 1983. Applying a value of $0.83 to every ton of erosion reduction achieved by targeting in the study area results in an average present value of over $300 per acre at a 12-percent discount rate and 50-year time period.

The only area where offsite effects were estimated in this study was in Washington state. Recognized examples of offsite damage of erosion in the study area are filling of creekbeds which increases flood damage, filling of recreational lakes with sediment, reducing storage capacities of hydroelectric storage of three reservoirs, degrading fish habitat, increasing dredging costs, raising roadside maintenance, and losing recreational facilities. Using data from the U.S. Army Corps of Engineers and local contractors, USDA estimated costs of two of these sources of offsite damage: dredging sediment from reservoirs behind Lower Monumental and McNary dams and removal of sediment from roadside ditches in the two study counties (11).

SCS estimates the sediment delivery ratio (percentage of eroding materials getting into the stream system) to be 16 percent for this watershed. Offsite damage during 1980-83 was reduced by $378,000. Reduction in damage per treated acre amounted to $4.82 in Columbia county and $7.35 in Walla Walla county, or $0.66 per ton of erosion reduction. The net present value of reducing sediment over a 50-year period, discounted at 12 percent, is $40.03 per treated acre in Columbia county and $61.04 in Walla Walla county.

Secondary

Targeting erosion control assistance can have economic consequences beyond farmers. Business people who buy, process, and market agricultural products or sell machinery, equipment, chemicals, and other inputs to farmers may also be affected by changes in outputs or use of inputs. In addition, expenditures by the government for technical assistance or cost-sharing of practices can affect community income flows. These secondary effects were estimated in the study areas by use of an input-output model called IMPLAN developed by the U.S. Forest Service to assist in local impact studies (8).

We estimated changes in annual production and technical assistance and cost-sharing funds as a result of targeting for each county in the study area. We used these data in the IMPLAN model to estimate changes in gross output and value added as a result of the targeting program in each county.

Results of the analysis indicate that targeting did not have a major effect on the economies of the study counties because there were no large changes in the level of agricultural production (table 3). In three counties, gross output declined slightly because of shifts to less intensive cropping patterns on a few acres. The value of goods and services produced went up slightly in the other five counties, mostly because of the increase in federal government expenditures for cost-sharing and technical assistance. This introduced money from outside the county and thus added more to the local economy than if the farmers had paid for the USDA services.

From a national perspective, agricultural secondary effects usually are not important to overall national economic growth because changes in one area are often offset by opposite changes in another area. For example, if reduction

Table 3--Secondary economic effects, 1980-83

State/county	Change in gross output		Change in value added	
	County	Per ton 1/	County	Per ton 1/
	1,000 dollars	Dollars	1,000 dollars	Dollars
Alabama:				
Barbour	-140	-5	-84	-0.39
Henry	21	1	12	.04
Missouri:				
Daviess	-32	-3	-8	-.03
Harrison	41	1	30	.19
Tennessee:				
Dyer	24	4	13	.02
Haywood	14	1	12	.02
Washington:				
Columbia	-80	-12	-70	-.28
Walla Walla	240	20	110	.34

1/ Per ton of erosion reduction.

in production in one area is made up by increases in production in other areas as market demand is met, the net change in the total national economy will be small. Likewise, federal cost-share funds and employee salaries in one area come from taxes (or borrowing) which reduces income flows elsewhere.

Conclusions from the input-output analysis are that unless erosion control programs result in significant changes in agricultural production in the county or bring in large amounts of state or federal funds, secondary effects are not very important. However, if a policy to take the most erosive lands out of production were implemented, secondary effects in counties where most cropland is highly erosive could be significant.

ANALYSIS

Base data available for estimating long-range productivity losses and erosion control effects differed considerably across study areas. In Missouri and Washington, considerable work had been done on economic effects of soil erosion. Little economic analysis of soil erosion existed in Alabama and Tennessee. In addition, definitions of conservation practices as well as management of conservation programs varied. Thus, procedures used to measure benefits and costs varied from state to state. Therefore, the four separate state studies cannot be aggregated in a meaningful way. Results and implications for each study area are first reported separately. Then, some overall conclusions are presented based on what was learned from each area.

Missouri

The study for Missouri is a detailed, comprehensive analysis of soil erosion as it relates to soil groups, land use, cropping patterns, erosion phase, USLE factors, and economic factors in Daviess and Harrison counties (5).

Daviess and Harrison were designated as highly erosive counties and targeted for additional conservation funds. The average annual soil erosion rate for all land was 9.6 tons per acre for Daviess and 8.9 tons for Harrison. The average erosion rate was 14.1 tons per acre for row crops and 17.6 tons for grain crops.

Combined SCS and ASCS expenditures for erosion control in the two counties in 1980 was $465,000, increasing in 1982 under targeting by 42 percent to $660,000. Combined funding dropped to $604,000 in 1983.

The nature of conservation programs has been shifting from one aimed primarily at water impoundment to long-term soil productivity. For example, in 1979 about 38 percent of conservation funds in Daviess county was spent on water impoundment or control structures, dropping to 9 percent by 1983. Comparable figures for Harrison county are 64 and 11 percent. Much of the shift went to terracing in both counties. In 1982, Missouri started a supplemental cost-sharing program. Most of these funds also went for assisting farmers with terracing, but about half of the funds for Harrison county went for reduced tillage.

Data used for this analysis were primarily from the 1982 National Resource Inventory (NRI); the Conservation Reporting and Evaluation System (CRES), a reporting system designed by USDA to provide data for evaluation of conservation programs of both SCS and ASCS; and the productivity index (PI) work by the University of Missouri.

Erosion Reduction

Sheet and rill erosion by soil group and land use was estimated using the USLE (table 4). Data on cost-shared practices adopted came from CRES data sheets. Soils were divided into four groups. Soil group 1, representing alluvial bottom lands, is least erosive. Flooding and poor internal drainage are principal problems in this soil group. Soil groups 2, 3, and 4 are progressively more erosive upland soils. Soil group 2 generally occurs at the crest of a hill and groups 3 and 4 occur on side slopes. Soil groups 2, 3, and 4 generally correspond to SCS land capability classes II, III, and IV.

Conservationists working with farmers emphasized adoption of conservation systems rather than single practices. A large number of combinations of practices were consequently cost-shared and adopted. Thirty-four such combinations occurred in study counties in Missouri, not all of which are designed to control erosion. The 21 affecting a USLE factor were used in the analysis. Other combinations included practices that addressed problems other than water-based soil erosion; for example, windbreaks and subsurface draining. Only the eight most important combinations are reported here. Definition of practices is from the Soil Conservation Service in Missouri. As reported by CRES, sheet and rill erosion reduction from adopting cost-shared conservation practices in the area ranged up to 30 tons per acre (table 5). Average erosion reduction for cost-shared practices in Daviess county was 10.31 tons per acre per year and 23.39 tons for Harrison.

Table 4--Annual sheet and rill erosion by land use and soil group, Missouri study area

County/land use	Soil group 1	2	3	4	Total
			Tons per acre		
Daviess county:					
Corn and sorghum	3.3	13.1	22.6	16.5	11.3
Soybeans	3.6	13.7	23.8	30.1	15.1
Wheat and oats	3.0	10.0	15.1	33.3	13.8
Other crops	2.4	10.5	17.4	19.2	12.9
Row and grain	3.4	13.0	21.6	30.0	14.1
Hay	1.1	.9	2.8	1.1	2.0
Pasture	.7	2.4	2.0	8.5	2.9
Forest	.1	.2	1.3	2.8	1.5
Average	2.6	10.0	12.6	14.8	9.6
Harrison county:					
Corn and sorghum	2.9	11.8	25.8	47.1	15.4
Soybeans	3.4	12.1	28.1	34.6	17.7
Wheat and oats	3.3	9.6	16.0	45.1	19.6
Other crops	1.7	2.0	26.0	41.2	22.7
Row and grain	3.1	11.4	24.1	39.9	17.6
Hay	.3	1.4	2.0	5.5	2.7
Pasture	.3	.8	1.9	5.1	2.7
Forest	.1	0	4	2.6	1.5
Average	1.9	7.6	11.4	11.6	8.9

Costs of Reducing Erosion

Costs of adopting conservation practices were shared by ASCS and farmers (table 6). Cost-share rates were variable. Reduced tillage was not cost-shared by the federal government for the most part but Missouri did some cost-sharing for minimum tillage. State cost-sharing is not included in this analysis. Daviess county used a greater variety of practices to reduce erosion on more acres than did Harrison county which mostly used terraces. In terms of cost per ton of erosion reduction, combinations that included terracing were most costly even though they were effective in reducing erosion. Adding conservation tillage and conservation cropping (using less erosive crop rotations) to terraces improved cost-effectiveness. Conservation tillage and conservation cropping alone had lowest cost per acre and per ton of erosion reduction, but there were only 558 acres cost-shared in the two counties. For Daviess county, the combination of contour farming, conservation tillage, and conservation cropping was much more cost-effective than practices that contained terracing, even though erosion reduction was not quite as large. In Harrison county, nearly all practices were cost-shared, including terracing.

Long-term Productivity

The relationship between soil depth and productivity was estimated using the University of Missouri productivity index model (5). The effects were simulated for various soils assuming existing cropping patterns and production

Table 5--Conservation practices, area covered, and erosion reduction, Missouri study area, 1981-83

Practice	Daviess county		Harrison county	
	Area	Erosion reduction	Area	Erosion reduction
	Acres	Tons per acre per year	Acres	Tons per acre per year
Terraces	120	7.19	4,041	18.97
Terraces and contour	500	11.17	663	26.21
Terraces, contour, conservation tillage, and conservation cropping	5,391	15.18	158	30.40
Terraces, contour, and conservation cropping	136	10.93	0	0
Contour, conservation tillage, and conservation cropping	11,284	8.90	0	0
Conservation tillage and conservation cropping	9,540	9.79	0	0
Conservation cropping	463	10.71	95	25.00
Pasture and hay management	903	10.37	555	25.81
All other	574	.27	1,221	34.36

Table 6--Conservation practice cost-sharing, Missouri study area, 1981-83 1/

Practice and practice combinations	Costs per acre				Costs per ton 2/			
	Daviess county		Harrison county		Daviess county		Harrison county	
	Farmer	ACP	Farmer	ACP	Farmer	ACP	Farmer	ACP
	Dollars							
Terraces	57.58	44.54	69.20	72.95	8.01	6.19	3.64	3.85
Terraces and contour	68.83	72.13	75.60	68.52	6.25	6.46	2.89	2.61
Terraces, contour, conservation tillage, and conservation cropping	69.08	57.02	77.16	85.56	4.55	3.76	2.54	2.81
Terraces, contour, and conservation cropping	100.39	70.11	0	0	9.18	6.41	0	0
Contour, conservation tillage, and conservation cropping	4.63	.06	0	0	.52	.01	0	0
Conservation tillage and conservation cropping	.12	0	0	0	.01	0	0	0
Conservation cropping	9.75	4.00	25.10	28.23	.91	.37	1.01	1.13
Pasture and hay management	10.37	35.13	25.81	56.16	3.39	1.95	2.18	1.36

1/ ACP = Agricultural Conservation Program, Agricultural Stabilization and Conservation Service, USDA.
2/ Costs per ton of erosion reduction.

practices (table 7). The present productivity indices for the average level of soil depletion in each soil group were estimated by using 1982 NRI data. Differences in productivity indices were used to estimate yields and net returns for each soil group and level of erosion.

The productivity indices along with current cropping patterns, prices, and yields were used to estimate value of each inch of soil eroded. Although

Table 7--Productivity index, Missouri study area

Inches previously eroded	Soil group							
	Daviess county				Harrison county			
	1	2	3	4	1	2	3	4
	Productivity index							
0	0.529	0.834	0.761	0.622	0.604	0.843	0.777	0.790
1	.526	.822	.742	.612	.597	.830	.764	.771
2	.523	.810	.724	.602	.590	.818	.751	.753
3	.520	.796	.705	.692	.583	.805	.768	.734
4	.516	.787	.686	.583	.575	.793	.725	.715
5	.516	.770	.671	.560	.568	.776	.710	.699
6	.515	.753	.656	.538	.562	.760	.696	.684
7	.514	.736	.641	.515	.555	.743	.681	.668
8	.514	.719	.626	.493	.549	.726	.667	.652

See (5) for complete index and details on how it was calculated and used.

losses for a particular soil group are different for the two counties, averages weighted by cropping pattern are remarkably similar (table 8).

Present Value

Results of applying present value procedures illustrated in figure 2 and table 2 to data from Missouri are reported in this section.

Benefits: Benefits of erosion control for this study are the present value of soil saved by adopting erosion control practices. Benefits were estimated by calculating crop yield difference with and without erosion control. Benefits come from reducing loss in productivity from erosion.

Applying discounting procedures to data in table 8 gives an estimate of present value of soil loss from the current level of erosion (table 9). The undiscounted accumulated loss for 50 years for soil group 4 in Daviess county was $1,096 per acre. When this accumulated nominal value was discounted at 4 percent, present value dropped to $297 and to only $49 at 12 percent. Thus, assuming that 12 and 4 percent are appropriate private and public discount rates, these values represent potential present value of eliminating erosion in this example.

Potential benefits of conservation measures can be represented by the difference in losses incurred with no additional conservation as represented by current erosion rates and those possible with conservation practices. If the present value of the initial practice and maintenance costs is less than these benefits, the practice is economically feasible. Any larger amount would represent a net loss. If a given conservation practice is the first adopted, it will reduce erosion more than if it is preceded by other

Table 8--Average annual loss in net income due to erosion, Missouri study area, 1981-83 1/

Soil group	Present erosion rate	Inches of soil previously eroded				
		0-4	4-8	8-12	12-16	16-20
	Tons per acre	Dollars per acre				
Daviess county:						
1	3.4	0.02	0	0	0.03	0
2	12.9	.32	.45	.54	.64	.32
3	21.6	.78	.65	.72	.01	.35
4	29.9	.79	1.30	1.45	.98	0
Average	14.1	.38	.34	.30	.27	.15
Harrison county:						
1	3.1	.05	.04	0	.02	0
2	11.4	.28	.38	.53	.62	.30
3	24.1	.57	.64	.68	.51	.57
4	39.9	1.40	1.17	1.26	.11	.63
Average	17.4	.39	.41	.36	.32	.21

1/ Annual loss weighted by cropping pattern.

practices. If multiple practices are adopted on a given acre, combined benefits will be less than the sum of the single benefits.

Costs: Table 6 costs are average annual costs of adopting and maintaining conservation practices. Estimating present values for costs involves the same procedures as for benefits. For each practice that was cost-shared, the soil group, erosion phase, erosion rate, and amount of erosion reduction were estimated. Costs for each year were estimated and discounted to present value with the appropriate discount rate.

Net Present Value: Subtracting costs from benefits for each year in the timeframe and calculating present value give a measure of net present value at the discount rate used. If the discount rate is the appropriate one, the result is the net benefits of adopting the conservation practice.

The system of conservation practices analyzed in Daviess county resulted in positive net present values at both 4- and 12-percent discount rates. In Harrison county, however, net present values were negative for most practices (table 10). For terraces, public net losses were larger than private net losses for the same reason that positive net benefits are usually larger; namely, present value of a series of negative benefits will be larger with a low discount rate than with a higher one. For the combination of terraces, contour, conservation tillage, and conservation cropping, public net benefits were positive while private net benefits were negative because of timing of costs and benefits. Highest costs occurred early in the timeframe. Benefits accrue throughout the timeframe, growing larger each year. The low public discount rate meant that large benefits toward the end of the timeframe had a greater present value, causing the net to be positive. But for the private discount rate, high costs early in the timeframe were not offset by more highly discounted benefits toward the end of the timeframe.

Economic Implications

Conventional wisdom holds that conservation tillage is economically feasible for farmers and need not be cost-shared. Conservation tillage has been introduced in Missouri, but is not cost-shared by the federal program. Instead, it is promoted as an accompanying practice to other practices which

Table 9--Present value of loss of income from current erosion rates, Missouri study area

Soil	Discount rate (percent)		
	0	4	12
		Dollars per acre	
Daviess county:			
1	31	9	2
2	401	120	24
3	993	303	61
4	1,096	297	49
Harrison county:			
1	61	18	4
2	358	108	21
3	752	224	44
4	1,612	497	103

are cost-shared. The analysis for Missouri indicates that conservation tillage was indeed economically feasible for both farmers and society in many situations (see 5 for details). Furthermore, the analysis suggests that if maximum benefits are to be obtained, conservation tillage should be the first increment in a conservation plan whether or not the practice itself is directly cost-shared.

For example, present value of productivity saved by zero tillage was about the same as for contour farming and terracing of soils with slope lengths greater than 200 feet. The major difference in feasibility of the practices lies in their costs. Terracing requires initial investments of from $100 to $160 per acre. Additional annual costs are incurred for terrace maintenance and contour farming. However, once farmers learn the technique, conservation tillage results in cost savings. Lack of large initial investments plus long-term cost savings result in significant benefits to both society and farmers. Daviess county had a positive net present value for cost-shared practices while Harrison county did not because conservation tillage was included in 91 percent of the acreages reported in Daviess county but only 2 percent in Harrison county. This difference does not imply that conservation tillage was not adopted in Harrison county. Rather, it indicates that conservation tillage was not reported as a part of conservation plans adopted by farmers receiving cost-sharing.

The conservation program was effectively targeted to the most erosive soils in both counties. About 91 percent of soils in Daviess county and all soils in Harrison county were classified IIe or greater. The major potential improvement in the program lies in targeting practices as well as soils.

Table 10--Net present value of cost-shared practices, Missouri study area, 1981-83

Practice and practice combinations	Daviess county			Harrison county		
	Area treated	Discount rate		Area treated	Discount rate	
		4 pct.	12 pct.		4 pct.	12 pct.
	Acres	Dollars		Acres	Dollars	
Terraces	121	-142.91	-90.88	4,041	-124.51	-100.78
Terraces and contour	500	-277.70	-149.05	663	-152.33	-130.17
Terraces, contour, conservation tillage, and conservation cropping	5,391	20.00	-40.08	158	70.42	-39.85
Terraces, contour, and conservation cropping	136	-340.57	-193.91	0	--	--
Contour, conservation tillage, and conservation cropping	11,284	213.29	68.56	0	--	--
Conservation tillage and conservation cropping	9,540	323.03	112.19	0	--	--
Conservation cropping	463	95.29	11.35	95	179.17	20.40
Pasture and hay management	903	50.24	-14.71	555	148.77	-9.17
All other	574	-136.22	-78.45	1,221	196.10	-8.45
Average		186.94	50.60		-37.73	-76.24

-- = Not applicable.

A note of caution is offered when interpreting results for Missouri. Some practices, such as terraces, may have a higher proportion of off-site benefits which are not evaluated in this analysis. In addition, CRES data used to represent systems of conservation practices often contained costs and cost-shares for accompanying practices which had little effect on sheet and rill erosion. The result is higher costs than if only those practices relating to sheet and rill erosion were included. Despite these limitations, the Missouri analysis does give a basis for ranking systems of practices reported in CRES data and an indication of feasibility of these practices. Targeting clearly could have been more economically efficient if more attention had been paid to economic costs and benefits of alternative practices, especially in Harrison county but also in Daviess county.

Washington

Columbia and Walla Walla counties encompass 1.36 million acres of land, including 100,500 acres of irrigated cropland, 675,000 acres of nonirrigated cropland, and additional amounts of rangeland, forested land, other land, and portions of a wilderness area. Base cropland acreage of the 181 farming operations covered by the targeting survey totaled 355,185 acres of nonirrigated cropland. Average farm size was 1,714 acres in Columbia county and 2,193 acres in Walla Walla county.

Numerous cropping systems were used in the study area in 1980. Two cropping systems in general use were alternative small grains and summer fallow, and alternative grains and field peas. Combinations and variations of these cropping systems in use included wheat-fallow, wheat-barley-fallow, annual spring barley, winter barley, annual wheat, and wheat-peas. Wheat-fallow rotation comprised approximately 83 percent of nonirrigated cropland in the study area. Nearly 50 percent of wheat-fallow rotation was grown on Class III soils.

Precipitation varies considerably in the study area. Four rainfall zones are defined: less than 12 inches, 12-15 inches per year, 15-18 inches, and over 18 inches. Annual cropping is not consistently practical when annual rainfall is less than about 15 inches. In these relatively dry areas, summer-fallow is included in the rotation to store moisture for two seasons to be used by a single crop.

Four large linear programming models were combined to construct a 1980 base for each study county. These models had been developed over a number of years for use in USDA river basin studies. Interrelationships among crops, conservation treatment measures, cropping systems, precipitation zones, and soil capability class were included in the model. Production costs and crop prices in the model allowed estimation of net returns. The model was updated to 1983 to reflect changes in cropping systems and adoption of conservation practices. Data for the update came from the farm survey that was part of the overall targeting study (2, 3). The model was used for evaluating erosion control in both a "with and without" and a "before and after" context. Thus, the analysis examines the agricultural economy before targeting and after 3 years of targeting and estimates benefits with conservation practices contrasted to a situation without them.

A useful feature of a linear programming model is its capabilities as an accounting tool. The model developed for these counties has over 1 million

data cells combined and aggregated in various ways. Selected data for treatment measures and cropping systems are reported in this section. As part of the analysis, numerous relationships among conservation practices, rainfall zones, and soil classes were examined as well.

Linear programming models are useful for asking "what if" questions. Results of three "what if" scenarios are reported at the end of this section. The first examined what happens to income if erosion is minimized, the second looked at what happens to erosion if profits are maximized, and the third estimated changes in both erosion and income if cropping patterns are changed.

The National Resource Inventory (NRI) system was used as a base for the physical resource data. The Land Inventory and Monitoring (LIM) survey in the area was an 8-percent sample making data reliable at the county level.2/ LIM sample sites provided basic data for the baseline model. Yield data were obtained from county ASCS offices for each sample point. These yields were supported by grain operators' elevator receipts for a 5-year period. Sheet and rill erosion rates for each LIM site within the study area were estimated using USLE.

The model estimated benefits and costs of applying conservation practices for each acre of dry cropland in each county. Soil type, rainfall zone, and cropping pattern were specified in the effort. Erosion rates and annual costs and returns were calculated. These data were used to estimate present value of adopting each conservation practice recommended by USDA.

The analysis measured only changes in cropping system or use of conservation practices from 1980 to 1983. The 1980 yields, costs, and returns were used to avoid including effect of changes in prices or yields due to weather or other external influences.

Availability of detailed data and an analytic model for the study area provided the basis for an analysis of all conservation practices, whether cost-shared or not. For the other states, only those conservation practices that were cost-shared were analyzed. For Washington, a brief summary of an analysis of only those practices that were cost-shared is reported.

Erosion Reduction

In 1980 prior to the targeting effort, average sheet and rill erosion rates for Columbia and Walla Walla counties were 9.30 and 12.15 tons per acre per year. By the end of the 1983 crop year, erosion rates had been reduced to 7.91 tons per acre in Columbia county and 11.49 tons in Walla Walla county by farmers shifting to less erosive farming practices, although there was a minor amount of erosion reduction that resulted from a slight reduction in acreage of more erosive crops (table 11).

Erosion was reduced by 573,400 tons annually by applying different levels of conservation practices (table 12). Low-residue tillage decreased 32,870 acres and medium-residue tillage dropped 11,957 acres (low residue is less than 500 pounds of residue per acre on the surface, medium is between 500 and 1,000 pounds per acre, and high residue is over 1,000 pounds per acre. Minimum

2/ LIM is an SCS nationwide survey providing detailed information on land use. The 3-percent sample provided state-level reliability. County-level reliability was possible with an optional 8-percent sample size.

tillage increased 22,980 acres while no-till farming expanded by 2,216 acres. Permament vegetation increased 1,143 acres.

Soil Productivity

The Soil Conservation Service, drawing on work by Agricultural Research Service and Washington State University, estimated loss of yield associated with loss of topsoil from erosion. For example, 1 inch of topsoil lost can reduce wheat yield by 2.04 bushels per acre in the study area. Present value of cost of yield losses from erosion was estimated using these data along with actual cropping patterns in 1980 and 1983; erosion rate for each crop, soil, rainfall zone, and conservation practice; and price of the product. A reduction in erosion will also reduce present value of loss in productivity due to erosion. Difference in present value of lost productivity in 1983 and 1980 gives an estimate of the benefit of adopting conservation practices during that period (table 13). A 50-year time period and a 12-percent discount rate were used.

The present value of soil productivity losses from erosion in the two counties dropped from $23.8 million in 1980 to $22.2 million in 1983 because of shifting to less erosive cropping systems and adopting conservation practices. Soil productivity savings (1980 minus 1983 in table 12) were $707,000 in Columbia county and $948,000 in Walla Walla county.

Costs of Reducing Erosion

Differences in net income between 1980 and 1983 reflect income changes due only to increased costs of adopting and maintaining conservation practices including loss from changing cropping patterns to reduce erosion. Changes in prices, crop yield, or other practices are excluded. Thus, cost estimates

Table 11--Area in various crop rotations and erosion rates, Washington study area

County/rotation	Area		Erosion rate	
	1980	1983	1980	1983
	1,000 acres		Tons per acre	
Columbia county:				
Wheat-fallow	164.3	162.9	9.47	8.18
Wheat-barley-fallow	5.6	4.7	8.30	5.40
Wheat-peas	4.2	4.1	11.93	10.26
Annual barley	.7	.7	3.47	3.47
Annual wheat	0	.7	0	3.82
Total	174.8	173.1	9.30	7.91
Walla Walla county:				
Wheat-fallow	379.2	378.3	13.49	12.69
Wheat-barley-fallow	2.8	2.8	4.49	4.38
Wheat-peas	65.7	65.6	12.62	12.51
Annual barley	.6	.6	.85	.85
Annual wheat	10.1	9.9	5.91	5.47
Total	458.4	457.3	12.15	11.49

Table 12--Conservation practices, acreage, and erosion, Washington study area, 1980-83

Practice	Columbia county				Walla Walla county			
	Area		Erosion		Area		Erosion	
	1980	1983	1980	1983	1980	1983	1980	1983
	1,000 acres		1,000 tons		1,000 acres		1,000 tons	
Low residue tillage	56.4	40.1	805.1	532.3	182.9	166.3	3,025.3	2,753.0
Medium residue tillage	51.4	46.2	397.2	333.3	139.5	132.7	1,718.3	1,613.6
Minimum tillage	25.3	34.9	81.2	105.6	48.1	61.4	416.8	431.4
No-till	0	.7	0	.7	0	1.5	0	1.8
Low residue and cross slope	3.5	3.5	72.9	74.0	11.9	11.9	105.1	103.2
Medium residue and cross slope	4.8	4.8	30.6	30.6	23.6	23.6	81.9	187.9
High residue and cross slope	.6	.3	1.3	0	5.6	5.6	4.4	4.4
Low residue and divided slope	0	0	0	0.	.6	.6	4.7	3.3
Medium residue and divided slope	0	6.0	0	57.7.	5.7	7.4	21.8	54.0
High residue and divided slope	0	4.3	0	12.1	0	5.5	0	23.8
Low residue and stripcropping	9.7	9.7	119.5	120.5	24.8	24.7	389.0	379.4
Medium residue and stripcropping	2.8	2.6	17.5	16.6	7.2	7.2	57.4	44.6
High residue and stripcropping	.7	1.0	3.0	3.5	6.6	6.6	76.4	0
Low residue and terraces	11.8	11.7	92.3	92.3	1.9	1.9	16.4	16.5
Medium residue and terraces	2.1	1.6	12.6	9.7	0	0	0	0
High residue and terraces	0	.2	0	.2	0	.3	0	0
Low residue, divided slope, and terraces	1.3	1.2	7.4	6.8	0	0	0	0
Medium residue, divided slope, and terraces	.7	.7	1.7	1.7	0	0	0	0
Low residue, stripcropping, and terraces	2.8	2.4	12.1	10.7	0	0	0	0
Medium residue, stripcropping, and terraces	.7	.7	1.2	1.3	0	0	0	0
Hay and pasture	2.1	2.1	.7	0	12.2	12.2	4.1	4.1
Bluegrass	0	0	0	0	0	0	0	0
Permanent vegetation	0	1.7	0	0	26.3	27.4	14.0	14.6
Total	178.3	178.3	1,658.3	1,409.6	490.6	494.9	6,035.8	5,711.0

reflect only costs of erosion reduction under targeting. Conservation measures incorporated in the study area depressed total net farm income by approximately $268,000 over the 1980-83 period: $148,000 in Columbia county and $119,000 in Walla Walla county. This amounts to about $0.47 per ton of erosion reduced (table 14).

Sixty-four percent of the net income decrease occurred in wheat-fallow rotation where annual precipitation exceeded 15 inches. On Class III lands, when converted to minimum tillage from low-residue tillage, net returns declined $0.92 per acre because of higher variable costs. Increases in no-till area reduced profits by $1.41 per acre in the high precipitation zone. An increase of nearly 2,800 acres of permanent vegetative cover cut profits an additional $33,000.

To estimate net benefits, one must extend both costs and benefits into the same timeframe. Table 15 presents comparisons of net present value of greater productivity from reduced erosion with 4- and 12-percent discount rates. A 50-year time period and no cost-sharing is assumed.

Small changes in discount rate can make large differences in present value estimates. When these practices were adopted, a 12-percent private discount rate approximated current interest rates. Interest rates have since dropped. Lower interest rates generally make investments in agriculture, including conservation practices, more profitable, assuming prices of inputs and outputs do not change.

The above analysis is based on all 355,185 acres of nonirrigated cropland in the study area. In Columbia county, 55,028 acres of conservation practices

Table 13--Present value of erosion reduction loss, Washington study area

County/rotation	Present value of lost productivity	
	1980	1983
	1,000 dollars	
Columbia county:		
Wheat-fallow	4,307.1	3,688.3
Wheat-barley-fallow	133.6	73.3
Wheat-peas	275.8	232.9
Annual barley	7.6	7.6
Annual wheat	--	15.2
Total	4,724.1	4,017.2
Walla Walla county:		
Wheat-fallow	14,154.8	13,285.5
Wheat-barley-fallow	36.5	35.7
Wheat-peas	4,593.3	4,544.8
Annual barley	1.7	1.6
Annual wheat	329.4	300.8
Total	19,115.8	18,168.2

-- = No acreage, thus no erosion.

Table 14--Net income changes caused by various conservation practices, Washington study area, 1980-83

Practice	Columbia county	Walla Walla county	Total
	1,000 dollars		
Low residue tillage	-1,008	-1,156	-2,164
Medium residue tillage	-437	-326	-763
Minimum tillage	717	788	1,505
No-till	53	159	213
Medium residue and divided slope	383	145	528
High residue and divided slope	227	259	486
Medium residue and stripcropping	-16	0	-16
High residue and stripcropping	23	0	23
Low residue and terraces	-16	0	-16
Medium residue and terraces	-38	0	-38
High residue and terraces	14	25	39
Low residue, stripcropping, and terraces	-30	0	-30
Permanent vegetation	-19	-14	-33
Total	-148	-119	-268

were adopted of which only 804 were cost-shared. In Walla Walla county, 51,804 acres of practices were adopted and 18,656 cost-shared. The actual area where practices were adopted was considerably less than this because many acres had more than one practice applied.

A separate analysis of only cost-shared practices using CRES data resulted in a positive average net present value to farmers of $28.12 for Columbia county and $28.16 for Walla Walla county (again, assuming a 50-year time period and a 12-percent discount rate). The same data and models used for the above analysis were used except only the acres that were cost-shared were evaluated and cost to farmers were reduced by the amount provided by the ACP. When farmers do not have to pay all costs, net returns are higher.

Table 15--Net present value of greater productivity from reduced erosion, Washington study area, 1980-83

County	Discount rate	
	12 percent	4 percent
	Dollars per acre of practice adopted	
Columbia county	-7	91
Walla Walla county	-6	158

Analysis of Alternatives

Erosion can be reduced by using conservation measures other than those adopted during 1980-83. The linear programming model was used to provide additional insights and implications of alternatives for reducing erosion. Results of three artificial alternatives designed to examine potential for erosion control in these counties are reported here. These alternatives are artificial because they look at maximums or minimums which in the real world can never be achieved for an area the size of these counties. However, the analysis does provide useful information for determining potential for conservation programs.

Alternative 1: The first alternative estimates minimum erosion possible by applying the most effective erosion control practices available to the existing cropping pattern. (If the cropping pattern were allowed to change, everything would go to permanent pasture for this alternative because it has the lowest erosion rate of all practices.) Results show that the erosion rate could be reduced to 0.87 tons per acre per year for Columbia county and 1.29 tons for Walla Walla county. Changing to the most effective practice reduced annual net returns by only about $7.50 per acre. Costs per ton of erosion reduction were only $0.89 in Columbia county and $0.50 in Walla Walla county.

The reason that these costs were so low is because in most cases the most effective conservation practice for the existing cropping pattern was reduced tillage. The two practices increasing most were no-till and high-residue tillage with stripcropping and terraces, implying substantial potential for further cost-effective erosion reduction in these counties.

Alternative 2: The second alternative asked if profits in 1983 could be improved. Again, the existing cropping pattern was fixed and practices allowed to change. But instead of minimizing erosion, the model maximized profits. By selecting the most profitable practices, farmers could have increased profits by $1.76 per acre per year in Walla Walla county and $2.03 per acre per year in Columbia county, levels less than 5 percent of average net returns. Erosion actually went down slightly because on some acres reduced tillage raised profits and reduced erosion at the same time. Quite a number of acres shifted from no-till and minimum tillage to reduced tillage (low- and medium-residue tillage) because of higher costs for chemical weed control on no-till. The conclusion from this alternative is that, given the cropping pattern, farmers in this area generally used the more profitable erosion control practices.

Alternative 3: The last alternative was designed to see if erosion could be reduced without reducing profits by changing cropping practices. Much erosion in the area comes from fallow ground in a wheat-fallow rotation. Research and field tests have demonstrated that in higher rainfall zones annual barley and annual wheat or wheat-barley-fallow rotations are profitable alternatives to a wheat-fallow rotation. Since these data were used to develop crop budgets that went into the model, the model shows these cropping patterns to be more profitable. For this alternative, there were major shifts out of wheat-fallow and wheat-peas and into annual wheat. Average erosion was reduced to below T value (the maximum soil loss that can be sustained without reducing long-term productivity of the soils) and profits went up. If current research results on continuous cropping are reliable, this alternative holds great promise for erosion control. Conservation agencies are aware of research being done on continuous cropping and are cooperating in further work.

Economic Implications

Erosion on dry cropland in Columbia and Walla Walla counties was moderately high. The conservation practices adopted from 1980 to 1983 were generally effective in reducing erosion. Annual net returns declined as a result of costs of adopting conservation practices, but by less than an average of $1 per acre. If practices adopted from 1980 to 1983 were maintained for 50 years, present value of productivity saved by reduced erosion for the county as a whole was over $1.6 million. When both costs and returns are assumed to continue for 50 years, average net present value of practices adopted from 1980 to 1983 was slightly negative with a 12-percent discount rate but positive with a 4-percent discount rate.

Erosion control from 1980 to 1983 lowered average erosion rates 15 percent in Columbia county and 5 percent in Walla Walla county. An analysis of alternatives concluded that farmers were generally efficient in using conservation practices, that there is still much potential for additional erosion reduction especially by use of high residue practices, and, if continuous wheat should prove as feasible as current research results show, erosion can be markedly reduced while increasing profits.

Alabama

At the time of this study there were no previous studies useful for economic impact analysis in the Alabama study area. This analysis is based largely on data collected from SCS and ASCS offices in each county.

Thirty-two of Alabama's 67 counties began targeting soil erosion control activities in 1982 and 1983. The two counties in this study, Barbour and Henry in the Southern Coastal Plains Major Land Resources Area (MLRA), were selected because they represent average targeting situations in Alabama. (See Basebook (2) for details on selection of study area.) Data for the analysis came from ASCS and SCS offices in each county. ASCS provided data on cost-sharing. SCS provided data on erosion rates for various soils and conservation practices, crop costs and returns, and crop acreages.

SCS targeted some assistance in Barbour county prior to 1982 but ASCS did not target cost-share funds until 1983. SCS increased staffing in Barbour county by 1.1 staff years in 1982 and 0.8 in 1983. Henry county staff years grew 0.5 in 1982 and 1.2 in 1983. The additional staff was for development of mini-long-term agreements and to intensify ongoing program efforts in addressing critical erosion problems. An LTA is a 6- to 10-year agreement covering all of a farm. A mini-LTA is a 3- to 5-year agreement that may cover only part of a farm. The following analysis for Alabama is based on cost-shared practices. It should be emphasized, however, that conservation technical assistance is an essential part of the erosion control process. Data on allocation of CTA costs to practices were not available.

The amount of annual and targeted cost-share funds increased by 103 percent for the 2 years in Barbour county and by 58 percent for Henry county (table 16). A total of 3,612 acres were cost-shared during 1982 and 1983, 912 of them charged against the targeting account. All practices were cost-shared at a 60-percent rate. Targeted cost-share funds were similar to annual cost-share funds except that they had to be used only for erosion control through mini-LTA's, and fields had to meet soil loss tolerance level (T) after implementation. Practices installed with annual and targeted funds were kept

separate during data collection and analysis. This separation turned out to be artificial because while separate accounts were kept little or no distinction was made between use of targeted and annual funds. Thus, effects reported here include erosion control using both targeted and annual funds.

Erosion Reduction

Average erosion reduction for Barbour county for the 1,898 acres that received cost-share payments was nearly 27 tons per acre. For Henry county, 1,749 acres were cost-shared with an average erosion reduction of 38 tons per acre. Erosion reduction for individual practices on cropland ranged from a low of about 2.5 to 33 tons per acre (table 17).

Very high rates for sod waterways in Barbour county and sediment retention control structures in Henry county resulted from dividing total erosion reduction for the area protected by number of acres to which the practice was applied. These practices trap soil and prevent it from leaving the farm, but do not prevent loss of soil productivity on cropped acres unless soil is moved back onto cropland from where it came.

Costs of Reducing Erosion

One measure of cost-effectiveness is ACP cost-share per ton of erosion reduction. If data were available, various other USDA costs should be accounted for, including SCS conservation technical assistance costs, Extension Service information costs, USDA administrative costs, and others. Data on CTA and other USDA costs were available for the county as a whole, but not by practice. On the average, CTA costs were about half of ACP cost-share. A rough approximation of both ACP and technical assistance costs can be made by multiplying ACP cost estimates by 1.5.

Average ACP cost-share per ton of erosion reduction was about the same for the two counties for the most used practice of terracing ($1.43 and $1.42), but average cost for Barbour county was one-third higher than for Henry county because of higher costs for several practices (table 18). Only 63 acres of reduced tillage (no-till) were cost-shared but cost per ton of reduction was about the same as the most cost-effective practice. Reported cost for permanent vegetative cover in Henry county appears out of line but was cost-shared on only 1 acre.

Farm Income

Adopting conservation practices increases fixed costs through investment in new machinery or structures such as terraces. Variable costs vary with use of

Table 16--Annual and target ACP cost-share funds, Alabama study area

County	1982	1983
	Dollars	
Barbour county	142,591	182,530
Henry county	105,598	106,688

inputs such as fertilizers or pesticides. If crop yields or cropping patterns change, net return will also change. Cost-sharing and technical assistance are needed to assist farmers in adopting recommended conservation practices that do not result in positive returns for the farmer. Even with cost-sharing, net returns declined for all practices cost-shared except for terrace systems in Henry county which increased net returns by $1.00 per acre. For this particular soil in Henry county, yields went up when terrace systems were installed, something that usually does not happen. Since terrace systems accounted for 83 percent of the acres that were cost-shared, average net returns for the county increased slightly.

There was a 48-percent drop in gross income from changing from peanuts to bahiagrass on 421 acres in Barbour county. Terrace systems with winter cover and no-till systems where peanuts changed to no-till corn also resulted in losses in gross and net returns in Barbour county. Average net returns for acres where conservation practices were cost-shared dropped by $46 (-24 percent) per acre annually in Barbour county but went up by $38 (13 percent) in Henry county (table 19).

Long-term Productivity

A national model called EPIC (erosion productivity index calculator) was being developed by ARS, ERS, and SCS as this study was underway. EPIC provides nationwide estimates of soil productivity associated with soil erosion. This data base provides general information about soils in the study area. Preliminary estimates from the EPIC model indicate that in this study area erosion has little or no effect on soil productivity. Thus, there would be no productivity gains from adopting conservation practices even though average erosion reduction of practices adopted was over 25 tons per acre. EPIC data

Table 17--Area and erosion reduction, Alabama study area, 1982-83

Practice	Area		Erosion reduction	
	Barbour county	Henry county	Barbour county	Henry county
	Acres		Tons per acre	
Terrace systems	780	1,424	28.17	32.83
Permanent vegetative cover establishment	581	227	23.69	43.52
Sediment retention control structures	155	72	44.74	127.44
Grazing land protection	212	0	2.49	--
Permanent vegetative cover on critical areas	80	1	66.69	149.00
No-till systems	63	0	8.00	--
Sod waterways	1	0	228.00	--
Total	1,898	1,749	26.75	37.73

-- = Not applicable.

combined with impressions from local conservationists indicate that erosion has only minor effect on crop yields on the deep leoss soils that make up most cropland in the area, but there is some loss. However, data are not available for estimating what these losses are. Also, because erosion rates are high, offsite damage is thought to be high. Because available data are not considered reliable for estimating productivity loss, no estimate of present value of erosion reduction is reported for Alabama.

Economic Implications

Farmers will not likely adopt and maintain conservation practices if doing so results in reduced net returns even with cost-sharing, especially if there are no long-term productivity benefits. Under these conditions, motivating farmers to adopt and maintain conservation practices that increase costs or lower yields will be difficult.

Alabama was the only study state to emphasize mini-LTAs. Some practices cost-shared in Alabama likely will not be maintained beyond the 3 to 5 years of the agreement. For example, there was a large reduction in net returns per acre when farmers converted peanut acres to grass. It seemed unlikely that farmers would switch from a highly profitable crop to low-value permanent pasture unless there were some benefits and even more unlikely that they would continue the practice over time. Inquiry as to why farmers adopted this practice revealed that in some cases the farmer shifted peanuts to other acres on the farm and thus did not actually reduce acreage of peanuts. Peanuts are more erosive than other crops; if farmers shifted peanut cultivation to other land on the farm, erosion on that land would have increased. Farmers could let land on which peanuts were grown "lay out" for a time while the mini-LTA

Table 18--ACP costs of conservation practices, Alabama study area 1981-83

Practice	Costs per acre		Costs per ton	
	Barbour county	Henry county	Barbour county	Henry county
	Dollars			
Terrace systems	39	47	1.43	1.42
Permanent vegetative cover establishment	48	45	2.03	1.04
Sediment retention control structures	115	190	2.58	1.49
Grazing land protection	31	--	12.33	--
Permanent vegetative cover on critical areas	70	875	1.05	5.87
No-till systems	9	--	1.11	--
Sod waterways	420	--	1.84	--
Total	49	52	1.85	1.38

-- = Practice not cost-shared.

requirement was being met. It is a normal practice for peanut farmers to rotate peanuts and pasture.

Development of onfarm conservation plans is a controversial matter. Some argue that a whole-farm conservation plan for each farmer receiving cost-sharing is needed in order to prevent farmers from inappropriate use of technical assistance and cost-sharing. Others believe that the detail required in developing a whole farm plan, most of which will never be implemented, takes time and effort that could better be spent "putting conservation on the ground." Perhaps the solution is to prepare a general whole-farm plan, but develop details for only that part of the farm most in need of treatment.

Tennessee

The analysis for Tennessee followed the same procedures as the Alabama analysis. Targeting efforts on areas with critical erosion problems occurred in 21 of Tennessee's 95 counties. The two counties selected in Tennessee for study were Haywood and Dyer, located in west Tennessee in the Southern Mississippi Valley Silty Uplands MLRA.

SCS accelerated the amount of staff assigned to the area. In 1977, each county had 2 staff years devoted to erosion control. Table 20 documents increases in subsequent years. The procedure used to administer cost-share funds varied for the two counties. A variable cost-share rate was used for Haywood county, while Dyer used a constant 50-percent cost-share rate for all practices. The variable cost-share rate was based on per acre erosion reduction after a practice was installed, times a severity factor based on the land's erosion rate before installation of the practice. Maximum cost-share rate was 75 percent.

Erosion Reduction

Terraces accounted for over half of the acres cost-shared and of the cost-shared funds in Haywood county (table 21). Erosion reduction averaged 16.9 tons per acre treated. Average erosion reduction for terracing, permanent cover, and sod waterways each exceeded 15 tons per acre. The Dyer county average reduction was 9.6 tons per acre with over 90 percent of the acreage in no-till or reduced tillage.

Table 19--Average returns before and after targeting, Alabama study area, 1981-83

Type of return	Before targeting	After targeting	Change
	Dollars per acre		Percent
Barbour county:			
Gross returns	547	382	-30
Net returns	190	144	-24
Henry county:			
Gross returns	622	653	5
Net returns	288	326	13

Table 20--Tennessee SCS staff added devoted to erosion control

County	1978	1979	1980	1981	1982	1983
			Number			
Haywood county	1.0	1.0	1.0	1.0	1.5	2.0
Dyer county	1.0	1.0	0	1.5	1.5	2.0

Costs of Reducing Erosion

In terms of cost-share cost per ton of erosion reduction, reduced tillage in Dyer county was the most cost-effective practice ($0.92 per ton). No-till was almost as cost-effective ($1.03 per ton). Cost of terracing on 3,105 acres in Haywood was lower than in other study counties because the kind of terraces built (gradient with no pipe outlet) is relatively inexpensive, averaging about $45 per acre. Terraces were not, however, more cost-effective in terms of cost per ton of erosion reduction, averaging over $2 per ton. Cost per ton of erosion reduction was lowest for the 46 acres in protective cover crop, followed by a larger acreage in sod waterways and no-till.

Terracing increased annual production costs in both counties by about $14 per acre. Switching from cotton to soybeans cost the farmer about $8 per acre in reduced net returns. A slightly higher yield estimated for no-till reduced

Table 21--Area, erosion reduction, and ACP costs, Tennessee study area, 1982-83

Practice	Area		Erosion reduction		ACP costs	
	Haywood county	Dyer county	Haywood county	Dyer county	Haywood county	Dyer county
	Acres		Tons per acre		Dollars per ton	
Terrace systems	3,105	30	17.11	14.00	2.02	1.90
No-till systems	629	4,742	12.01	9.35	1.92	1.03
Reduced tillage systems	0	1,212	--	8.68	--	.92
Cropland protective cover	46	0	13.93	--	1.22	--
Sediment retention structures	670	0	5.42	--	5.71	--
Sod waterways	707	0	18.51	--	1.78	--
Permanent vegetative cover	972	299	18.57	13.28	2.14	1.62
Permanent vegetative cover improvement	0	61	--	11.67	--	2.79
Permanent vegetative cover on critical areas	0	37	--	19.27	--	4.35
Total	6,129	6,381	16.90	9.51	2.08	1.83

-- = Zero acres cost-shared, thus no effects.

its costs (by increasing net returns) by about $2 per acre in both counties and reduced tillage reduced costs by $6 per acre in Dyer county.

Long-term Productivity

EPIC data were judged by conservationists to provide a good estimate of productivity losses for these counties in Tennessee. Productivity loss estimates for various land capability classes follow in table 22.

Present Values

Using discounting procedures, we estimated average (weighted by cropping pattern) present value of reducing erosion for each practice assuming a 50-year timeframe and 4- and 12-percent discount rates (table 23). There was considerable difference in present value of productivity maintained among practices and crops. Crops with higher net returns had higher benefits from erosion reduction. Of course, practices with the highest level of erosion reduction had the highest present value of soil saved.

Estimates of present value of erosion reduction were weighted by both cropping pattern and practices adopted. Annual costs of adopting practices varied from $14 for terrace systems to a cost savings of $2 for no-till in Haywood county and $6 savings for reduced tillage systems in Dyer county. The majority of cost-shared practices on cropland in Haywood county was for terrace systems. Terraces were effective in reducing erosion and provided one of the largest benefits of productivity saved of any practice. However, cost of terracing was so high that average net present value for Haywood county was negative (table 24). Dyer county, on the other hand, not only benefited from productivity saved, but also from reduced costs for both no-till and reduced tillage. Since these two practices made up over 90 percent of the practices cost-shared, production costs went down and net benefits were the sum of cost savings and value of productivity saved.

Economic Implications

Tennessee provides a good example of why estimates of offsite damage are important. Haywood county had high erosion reduction (and presumably high offsite benefits from damage reduction), but low onsite benefits. Average erosion reduction for Haywood county was 16.9 tons per acre per year, contrasted to 9.6 tons in Dyer county. But, Dyer county had a positive onsite net present value for practices adopted under targeting, while Haywood did not. Haywood county, using mostly terraces, considerably reduced erosion but at a high cost. Dyer county used mostly reduced tillage. While erosion

Table 22--Estimates of productivity losses due to erosion

Land capability class	Inches of erosion				
	0	2	4	8	16
	Productivity index				
2e	100	98	97	94	91
3e	100	99	98	94	90
4e	100	99	98	96	91

Table 23--Present value of erosion reduction, Tennessee study area, 1982-83

County/practice	Discount rate (pct.) 12	4
	Dollars per acre	
Haywood county:		
Terrace systems	38.98	196.30
Cover establishment	42.40	213.53
Dyer county:		
Terrace systems	31.92	160.72
No-till systems	21.43	107.91
Reduced tillage systems	19.84	99.87
Permanent vegetative cover establishment	31.00	156.13

reduction was not as high as in Haywood county, Dyer production costs actually went down. Farmers gained both from erosion reduction and from lower costs.

If offsite damage was high, total onsite plus offsite benefits of controlling erosion may be higher for Haywood county than for Dyer county. Assuming a 4-percent discount rate and a 50-year timeframe, offsite benefits would have to be $0.94 per ton for total public benefits to be equal for both counties. If offsite damage reduction was worth more than $0.94 a ton, public benefits and economic efficiency of erosion control for Haywood county would have exceeded Dyer county. If offsite benefits were less than $0.94 a ton, public benefits would have been greater in Dyer county.

Table 24--Average net present value, Tennessee study area, 1982-83

County/value category	Discount rate (pct.) 12	4
	Dollars per acre	
Dyer county:		
Present value of productivity saved	72	21
Present value of changing practices 1/	12	5
Net present value	84	26
Haywood county:		
Present value of productivity saved	218	38
Present value of changing practices 1/	-243	-97
Net present value	-63	-56

1/ When practices changed, costs decreased in Dyer county, but increased in Haywood county.

To the extent that practices substitute for each other, it would be most economically efficient to apply those practices with lowest cost per ton of erosion reduction. This generally means selecting reduced tillage rather than terraces, even though erosion reduction per acre for terraces is usually substantially higher. However, there are cases where terraces are necessary to get effective erosion control. It may be especially important to consider terracing where erosion rates are very high and where offsite damage is known to be high.

IMPROVING ECONOMIC EFFICIENCY

Economic efficiency is improved when net present value is greater when conservation practices are adopted. To be complete a measure of economic efficiency should include offsite benefits. But for selecting practices and estimating long-term productivity, onsite estimates alone will generally provide adaquate measures.

Practice Selection

Long-term productivity benefits are important to farmers but installing conservation practices that reduce current income as little as possible is also important. With a discount rate as high as 12 percent, distant productivity savings have a low present value. Thus, from a farmer's perspective, some form of conservation tillage is usually preferable to practices that have a high initial cost, such as terraces. Cost of erosion reduction generally could have been reduced if low-cost, low-investment practices had been considered first. When erosion cannot be controlled with these, other practices like terraces or diversions that are more effective but also more costly could have paid off.

But, conservation practices are not perfect substitutes for each other, and there are times when terraces or diversions may be the only way to adequately reduce erosion on certain fields. Also, from the national perspective, terraces or diversions may be more desirable when they are more effective in reducing erosion. With a lower discount rate and when reduction in offsite damage is important, the more costly but more effective practices may provide the highest net benefits.

The ACP program is not intended to provide assistance to farmers for practices they will adopt on their own, or for practices aimed at higher production. SCS encourages farmers to adopt conservation tillage, but usually does not cost-share it. Even less cost-sharing of conservation tillage is planned. In many areas, conservation tillage has increased greatly without cost-sharing. About one-third of the cropland now uses some form of conservation tillage. But there are other areas where it may be valuable where it has not been widely adopted. There were opportunities to improve economic efficiency of the program and increase benefits to farmers by greater use of conservation tillage in all four study areas.

Economic efficiency of the targeting program in the study areas would have been improved if conservation tillage were the first increment evaluated in any erosion control conservation plan and if it were easier to cost-share conservation tillage when it is the best way to reduce erosion. Careful conservation planning within a county could have assured that the ACP program did not provide a windfall gain to farmers who would have adopted conservation tillage on their own.

Long-term Productivity

Much progress is needed in developing capability to reliably estimate long-term productivity effects. Nevertheless, much progress has been made. There are enough data, models, and analytic capabilities for estimating long-term productivity to begin estimating productivity gains for each farm that receives CTA and ACP assistance for erosion control. We found that even with a 12-percent discount rate, present value of erosion control benefits can be significant. But net benefits varied widely among areas. Allocating erosion control funds based only on cost-effectiveness per ton of erosion reduction leads to inefficiencies because benefits per ton vary among areas and soils.

Offsite Effects

Several studies suggest offsite benefits may be as important or more important than onsite effects. If this is the case, and if offsite damage from a ton of erosion varies widely across the country (as it almost surely does) much more attention needs to be given to finding ways to attribute offsite damage to decisions made on the land. Because of complexity of the job, progress is likely to be slow. However, because of the importance of offsite damage, better estimates could lead to significant improvements in erosion control programs.

Conservation Planning and Evaluation

A major conclusion of this study is that economic efficiency of erosion control programs could be improved if targeting were based on economic criteria rather than just physical measures. While cost-effectiveness is a better measure than tons of erosion reduced, greater economic efficiency gains are possible if both benefits and costs are included in evaluation of erosion control options. A recent ERS study on the conservation program concluded that the 1983 overall U.S. erosion control program had a benefit-cost ratio ranging from 0.3 to 0.9, including offsite benefits which made up nearly two-thirds of the benefits (7). This analysis of targeted areas concludes that in each of eight counties studied there were erosion control practices adopted where net onsite benefits were positive. At the same time, there were conservation practices cost-shared in each county where onsite net benefits were negative.

USDA ideally would provide cost-sharing assistance to farmers when the present value of net benefits from adopting conservation practices to farmers is negative but the national economic efficiency benefits are positive. This could happen by counting offsite benefits as a national benefit but not as benefits to farmers, or because the difference in discount rates would cause the present value to be negative for farmers but positive at the national level. If net benefits to farmers are positive but some farmers are not adopting the practice, technical assistance or providing information to farmers may be an appropriate role for USDA.

The key to improving economic efficiency of the program is selecting soils and practices where net benefits are highest. This generally means selecting highly erosive soils for treatment and using some form of reduced tillage as the basic conservation practice. A combination of practices is sometimes more efficient than a single practice. When this is the case, it usually involves conservation tillage in combination with one or more other practices.

While recognizing that offsite benefits may be very important, we found no way to reliably estimate them for the study areas. As data on offsite benefits become available, they should be included in evaluation of benefits and costs. Considerable work on estimating offsite benefits is underway. As improved procedures for estimating offsite benefits become available, they should be applied by the conservation agencies. Until reliable estimates of offsite benefits are available, it will not be possible to determine which areas, soils, and practices provide the greatest erosion control benefits.

Recent increases in availability of data needed for conservation planning (such as NRI and CRES) along with general availability of personal computers and various software packages have made it feasible to estimate economic benefits and costs of adopting conservation practices at the farm level. Two examples of microcomputer models that estimate both costs and benefits of adopting conservation practices on individual farms are the COSTS model and SECAP (soil erosion crop analysis plan), both developed by authors of this report. SCS is beginning to make use of various similiar software programs.

Further improvements in data are needed. The 1982 NRI, just being completed when this study started, provides a valuable data set for quantifying the physical nature of erosion problems. Inclusion of USLE factors provides data needed for a powerful analytical model for evaluating physical effects of alternative conservation practices.

CRES also provides useful information for analyzing program effects. CRES data are available on an annual basis, a useful feature. However, the CRES data set would be much more useful for analytic purposes if it also included USLE factors. The USLE factors would permit analysis of practices primarily affecting onsite sheet and rill erosion and, consequently, soil productivity. Further, reporting practices may need to be improved in order to increase reliability of CRES data. For example, distinction between targeted and annual funds was reported through CRES even though there was no overall criteria for differentiating investments. In addition, some of the information was counterintuitive, calling into question the accuracy of the reporting. Discussions with various staff required to use the forms made it clear that while some employees are committed to making the system work as well as possible, others see the forms as unnecessary paperwork and are not as careful in completing them. Such problems should be eventually reduced and CRES data should become increasingly useful.

Development of models specifying the relationship between soil productivity and levels of depletion provides the means for quantifying long-term benefits of various conservation practices. These models can be used to help target conservation efforts on the basis of economic benefits and costs which is quite different from the physical measures now being used by conservation agencies. Further development of models such as EPIC and the productivity index used in this analysis would improve analysis of erosion control alternatives.

Some ways to assure economic efficiency in erosion control programs are:

* Target highly erosive areas.

* Target areas where offsite damage is known to be high.

* Target areas where productivity loss is important.

* Evaluate conservation tillage as the first increment in each plan.

* Whenever practices are cost-shared, estimate both public and private net benefits and cost-share those practices that maximize public benefits.

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UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMIC RESEARCH SERVICE
1301 NEW YORK AVENUE, NW.
WASHINGTON, D. C. 20005-4788